Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #48427

Integrating STEM Disciplines to Transform Indonesia's Educational Landscape: An Evaluation of the 'Merdeka Belajar' Curriculum Implementation

Mrs. Fadhla Binti Junus, Purdue Engineering Education

A former Assistant Professor and Tenured Lecturer in Information Technology at the Department of Science and Technology, State Islamic University Ar-Raniry, Banda Aceh, Indonesia. Currently pursuing a Ph.D. at the School of Engineering Education, Purdue University, Indiana, USA. Her research uniquely combines industry experience with academic expertise, focusing on technology-enhanced learning. Specifically, her work centers around developing personalized learning environments for higher education students studying computer programming. She is particularly interested in investigating students' programming learning processes, exploring methods to simplify programming instruction, examining theoretical foundations for effective instructional design, and integrating artificial intelligence technologies to facilitate peer-like knowledge construction.

Alfa Satya Putra, Purdue University at West Lafayette (COE)

Alfa Satya Putra is a 3rd year PhD student at School of Engineering Education at Purdue University. He has Bachelor's and Master's degree in Electrical and Computer Engineering from Purdue University. Before joining the PhD program, Alfa has served as a lecturer in Indonesia. Alfa is mainly interested in investigating the implementation of reflective activities in large classrooms and assessing how reflective activities affect student learning and academic performance.

Integrating STEM Disciplines to Transform Indonesia's Educational Landscape: An Evaluation of the 'Merdeka Belajar' Curriculum Implementation

Executive Summary

This paper evaluates Indonesia's 'Merdeka Belajar Kampus Merdeka' (MBKM) curriculum, launched in 2019, which aims to transform the nation's education system to meet 21st-century demands and prepare students for the Fourth Industrial Revolution. The MBKM curriculum emphasizes four key strategies: (1) in-depth learning approaches, (2) formative and holistic assessments, (3) teacher leadership development, and (4) integrating Science, Technology, Engineering, and Mathematics (STEM) disciplines into existing subjects to enhance critical thinking and problem-solving skills. Despite its ambitious goals, the implementation of MBKM has faced significant challenges. Geographical disparities across Indonesia's 17,000 islands, the COVID-19 pandemic, unequal access to technology, and coordination gaps among policymakers, educators, and administrators have hindered progress. These obstacles have led to inconsistent curriculum application, jeopardizing its full implementation by the 2024 target. A detailed evaluation of historical and current education policies highlights a critical shortfall: the integration of STEM disciplines into existing subjects has been insufficient. To address these issues, this report recommends the following actions: (1) Adopt a decentralized approach to curriculum governance for flexibility across regions, (2) Align educational content with industry demands to enhance relevance, (3) Decentralize decision-making to empower local stakeholders, (4) Upskill educators to improve their capacity for delivering the curriculum, (5) Promote creative thinking by integrating technology into teaching practices. By implementing these strategic recommendations, Indonesia can overcome the challenges of the MBKM curriculum and ensure the long-term success of its educational reform efforts.

Problem Definition

Indonesia's national curriculum, "Merdeka Belajar," is a bold initiative that aims to integrate the Science, Technology, Engineering, and Mathematics (STEM) disciplines within existing subjects, simplifying learning and enhancing students' critical thinking and problem-solving skills to prepare them for the demands of the 21st century and the "Industrial Revolution 4.0." However, its implementation is not without its share of challenges. The disruptions caused by COVID-19 and shortcomings in policy execution have posed significant hurdles. According to the Programme for International Student Assessment (PISA), as reported by [15], Indonesia demonstrated the influence of the COVID-19 pandemic, with achievement levels in mathematics, science, and reading being the most inferior ever recorded. PISA data in 2022 shows that Indonesian students' mathematics, science, and reading competencies lag behind other nations, scoring significantly below average for all three subjects and being ranked 69th, 67th, and 71st out of 81 nations. The scores recorded in 2022 show a declining trend since 2015 and are among the lowest ever recorded for Indonesian students in all three subjects [1]. Additionally, a study by [2] underscores the unequal access to technology, online learning difficulties, and limitations on collaboration as key factors hampering student engagement and knowledge retention. Moreover, a lack of coordination between policymakers, educators, and administrators [3] has led to inconsistencies in implementing the curriculum across all education levels. These challenges underscore the urgency and importance of addressing these issues to ensure the success of the "Merdeka Belajar"

curriculum. This paper aims to provide a critical overview of the challenges faced by the Indonesian educational system in implementing its national curriculum, particularly in STEM education. By understanding these challenges, this paper may assist policymakers in developing recommendations to minimize potential risks associated with educational policy implementation.

Context/Literature Review

As a public policy, curriculum is a collective term for the rules and regulations created by the executive and legislative branches of government to solve a public issue [4]. While curriculum changes can be disruptive, ongoing evaluation and adaptation based on educator needs and evolving societal demands are essential for fostering a dynamic and effective educational system in Indonesia, particularly in STEM fields. Research shows that educators experience various challenges in implementing STEM learning policies, spanning from K-12 to higher education. At the K-12 level, Arlinwibowo et al. [5] and Nugroho et al. [6] stated that Indonesian teachers struggle with effectively managing the teaching of STEM subjects due to their limited understanding of STEM learning and its underlying principles, especially in classrooms where students come from diverse backgrounds, possess varying levels of knowledge, and have different interests. Additionally, complex learning management, limited infrastructures to support STEM learning, and limited teacher professional development programs further impede the effective implementation of STEM learning policies. Furthermore, a lack of government support, insufficient learning infrastructures, disconnection between policymakers and policy implementers, outdated curriculum structures, and centralized governance of the education curriculum have hampered the successful implementation of the STEM policy at both the K-12 and college levels [5], [7], [8], [9]. Moreover, the COVID-19 pandemic further hindered student participation and learning outcomes [2], particularly in integrating STEM learning policies with Indonesia's most recent "Merdeka Belajar" curriculum.

The Indonesian education system has undergone significant development. Having been influenced by the Dutch and Japanese occupation that eventually evolved into a 12-year compulsory education adhering to a 6-3-3 structure (six years of primary school, three years of junior high school, and three years of high school/vocational school), the educational system in Indonesia also provides access to higher education as a non-compulsory education for its people [10]. Further report by [10] disclosed that enrolment rates dramatically increased among children aged 7 to 12, from 69% in 1973 to 83% by 1985. In 2018, the Indonesian Ministry of Education reported that almost 97% of children between 6 to 12 years old attended primary school, and 82% of children continued their education in a secondary school [11]. Moeliodihardjo [8] and Sukmayadi & Yahya [10] describe five types of institutions that offer higher education programs: academy, polytechnic, college, institute, and university. Academy and Polytechnic focus on vocational education programs targeting students aged 17-21, while the other three institutions focus on general academic programs for students of all ages. Both compulsory and non-compulsory education systems have encountered similar challenges related to curriculum changes throughout Indonesian history. According to the literature [5], [6], [9], [12], [13], the challenges include the following: (1) Content prescription: The curriculum focuses on content mastery, neglecting student competency levels and regional variances, leading to less engaging learning experiences; (2) Lack of flexibility: The centralized governance limited flexibility for schools and teachers to customize teaching strategies based on individual needs; (3) Curriculum constraint: The curriculum is not designed to promote integrative education and often obstructs the

implementation of STEM learning; (4) Insufficient focus on creativity and innovation: The curriculum discourages students to think critically, logically, and systematically as it relies heavily on memorizing; (5) Less relevant to job market: The education system struggles to keep pace with industry demands due to infrequent curriculum updates and a lack of industry involvement in curriculum development; and (6) Lack of involvement in professional learning communities: The curriculum limits teachers' participation for professional development and information change.

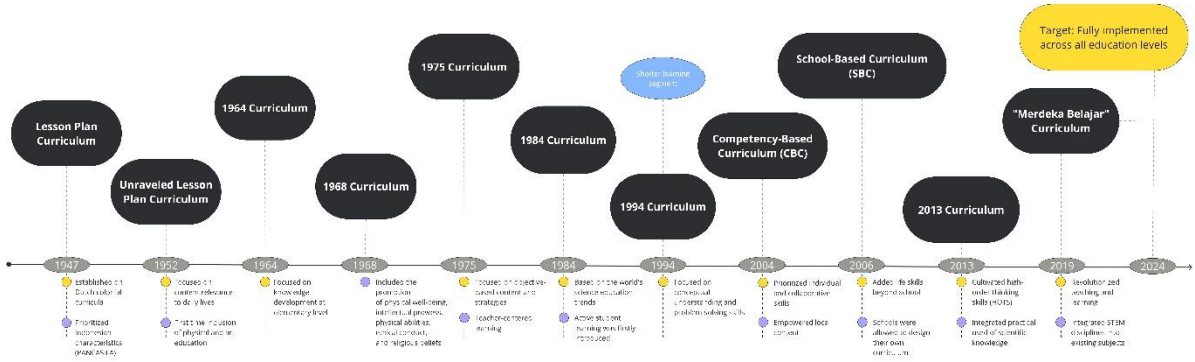
Given such challenges, it is critical to transform the curriculum for the Indonesian educational system. The transformation should emphasize the connection between academic content and industry demands, educators' upskilling, creative thinking and innovation, and governance decentralization.

Policy Description

The Indonesian education system has experienced substantial changes in curriculum design that built upon the country's long curriculum history. During the Dutch colonial era, which lasted for 350 years, the primary goal of education was to enhance the capabilities of the local population and establish a middle-class worker. This was achieved by teaching reading, writing, mathematics, and the Dutch language skills, as well as promoting Dutch culture while suppressing Indigenous languages and cultures for social control [4]. Then, since its independence in 1945, Indonesia has gone through multiple cycles of curriculum revision. Literature shows that the curriculum has been changed in order to align with the evolving educational paradigm and meet the demands of society. Haridza & Irving [14] and Rizaldi & Fatimah [2] traced the timeline of curriculum changes prior to the implementation of the most recent curriculum, "Merdeka Belajar," as follows: (1) **Lesson Plan Curriculum (1947)**: Although this curriculum was based on Dutch colonial curricula, it had the primary objective of fostering Indonesia's autonomy, sovereignty, and equal opportunity to education after its independence in 1945. The curriculum prioritized national interests by allocating a list of subject matter and time to build Indonesian characteristics based on the Five Basic Principles of the state philosophy (Pancasila); (2) **Unraveled Lesson Plan Curriculum (1952)**: This was the first curriculum revision in which provided more emphasis on the relevance of subject matter content and students' daily lives. It also broke new ground by including physical education and art education; (3) **1964 Curriculum**: It aimed to improve academic understanding at the elementary level and emphasized knowledge development and practical, functional activities, including creativity, values, participatory skills, craft, and morale of students; (4) **1968 Curriculum**: This curriculum incorporated the cultivation of life in accordance with Pancasila, encompassing essential knowledge and specialized skills to ensure the fulfillment of the human rights of Indonesian citizens. This includes the promotion of physical well-being, intellectual prowess, physical abilities, ethical conduct, and religious beliefs; (5) **1975 Curriculum**: It focused on objective-based content and strategies, with teachers given the responsibility of identifying and arranging instructional materials; (6) **1984 Curriculum**: In response to the current trends in science education at that time, the concept of active student learning was introduced for the first time by encouraging students to do more hands-on activities like observation, classification, and reporting; (7) **1994 Curriculum**: This curriculum enabled students to learn within shorter segments by changing the one learning year to three trimesters, which aimed to give students more opportunities to

develop their conceptual understanding and problem-solving skills gradually; (8) **Competency-Based Curriculum (CBC) 2004**: The curriculum prioritized developing well-rounded students with both individual and collaborative skills. It offered flexibility to adapt to societal changes and empowered local areas to design content that addressed their specific needs; (9) **School-Based Curriculum (SBC) 2006**: This curriculum allowed schools and school committees more freedom to design their own curriculum as long as the curriculum design included standardized competencies set by government and life skills to prepare students for life beyond school; and (10) **2013 Curriculum**: This curriculum emphasized fundamental skills, multicultural understanding, the cultivation of high-order thinking skills (HOTS) and integrating life science, environmental science, and the practical use of scientific knowledge. Fig. 1 depicts the history of Indonesian curriculum changes since its independent day until now.

Fig. 1. History of Indonesian Curriculum Changes



A new curriculum reform launched in 2019, the “Merdeka Belajar,” was built on the experience gained from the six-year implementation of its predecessor, “the 2013 Curriculum”, which faced criticism for its rushed implementation, unclear focus, and excessive stress on rote learning. The “Merdeka Belajar” curriculum, also known as the “Emancipation Curriculum,” represents a transformative educational reform initiative in Indonesia towards a more adaptable and inclusive education system [9], [15]. When it was first introduced by the Ministry of Education and Culture of the Republic of Indonesia, it came with its primary goal of revolutionizing teaching and learning as an effort to prepare students for the demands of the 21st century and the “Industrial Revolution 4.0” [4], [15]. To achieve this goal, the government encourages both compulsory and non-compulsory education systems to (1) incorporate in-depth learning approaches through discussion, group work, problem-solving, and project-based learning; (2) include a shift towards formative and holistic assessment methods; (3) emphasize the development of teacher leadership; and (4) integrate STEM disciplines into existing subjects [2], [9], [15], [16]. The government also set a target that the curriculum must be implemented at all levels of the education system by 2024 [2], [15].

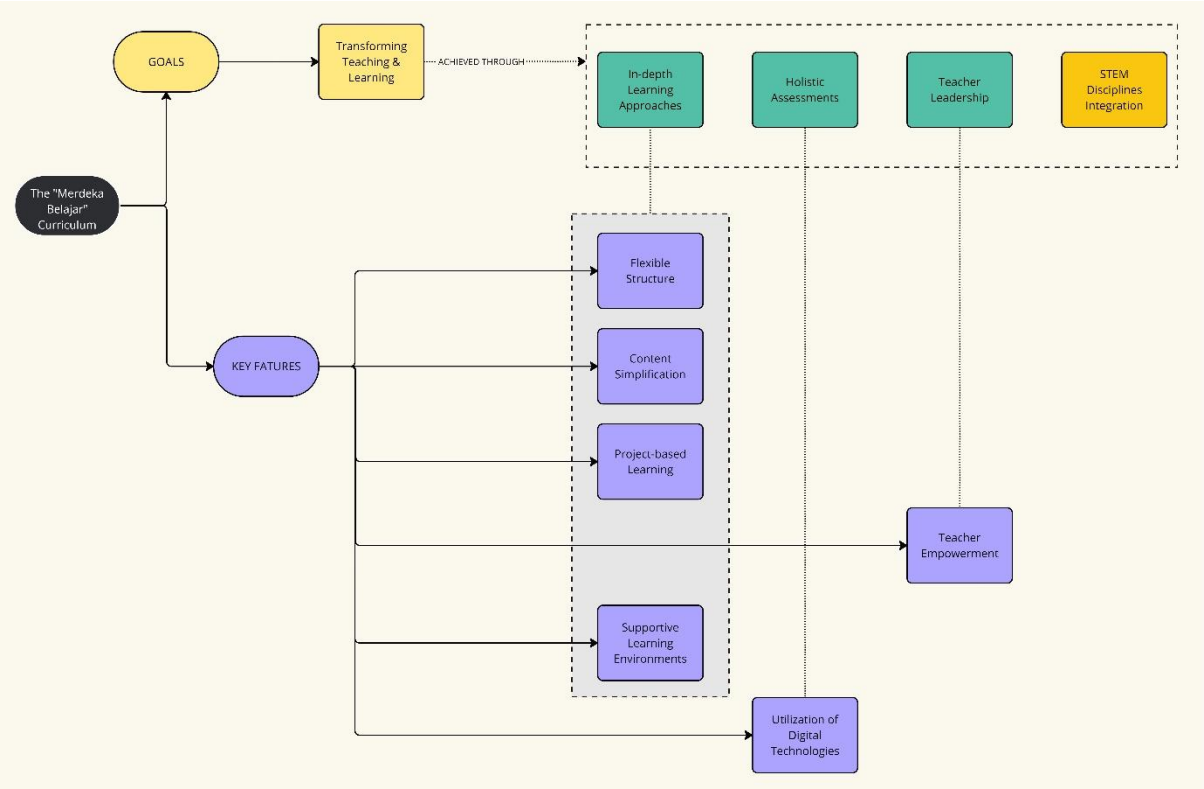
The “Merdeka Belajar” curriculum encompasses a diverse and comprehensive approach to learning, characterized by several key features as highlighted by [2], [4], [9], [15], [16]. Firstly, it simplifies content by focusing on fundamental skills such as reading and math, which helps students develop a more profound comprehension of key topics by reducing the amount of curricular content by 30-40%. Secondly, it promotes educational creativity,

specifically through project-based learning initiatives. This pedagogical approach empowers students to work together to solve practical problems, fostering a sense of accountability and active participation in their educational experience. Thirdly, it encourages flexibility, allowing instructors the autonomy to customize lessons to cater to their students' varied requirements, thereby cultivating a more individualized and attentive educational encounter. In addition, it prioritizes teacher empowerment by promoting professional development and increasing collaboration among teacher communities. Furthermore, the curriculum emphasizes the well-being of students, fostering a supportive and enjoyable learning environment that focuses on developing social-emotional skills and student agency. Finally, the curriculum utilizes digital technologies to facilitate communication, collaboration, and the sharing of effective teaching and learning practices.

Policy Evaluation and Discussion of Policy Alternatives

Drawing from the description of "the Merdeka Belajar" curriculum above, Fig. 2 presents a general framework outlining the connection between its core objective and key characteristics. Overall, while the emphasis leans towards the government's initial drive in achieving its goal—primarily through the adoption of in-depth learning approaches, the integration of STEM disciplines does not appear to be explicitly supported by the listed features of this education policy.

Fig. 2. The "Merdeka Belajar" Framework

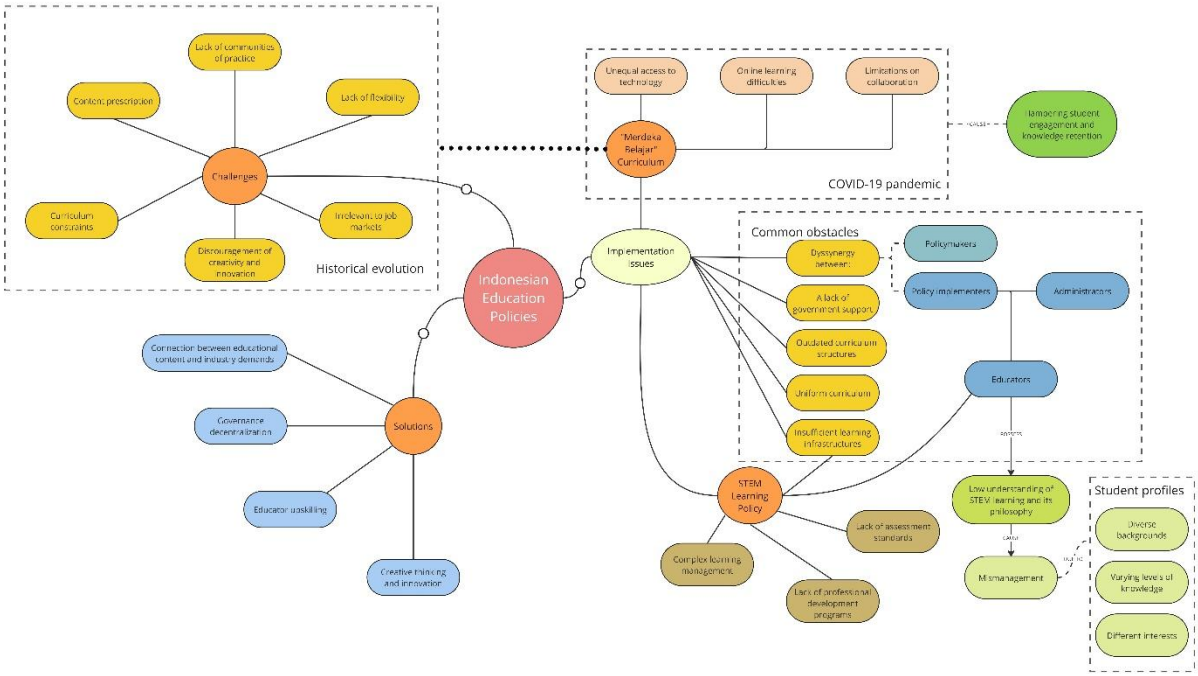


The absence of key features facilitating the integration of STEM disciplines within the execution of the "Merdeka Belajar" curriculum contradicts the original purpose of educational reform in Indonesia. As stated in the Policy Description section above, the reformation of the previous Indonesian curriculum to the "Merdeka Belajar" initiative is not

only to improve education but also boost critical thinking and problem-solving to prepare students for the demands of the 21st century and the “Industrial Revolution 4.0” skills. Research by Farwati et al. [16] and Veza et al. [12] emphasizes the importance of STEM education in equipping students for this demanding future, highlighting the need for a workforce with critical thinking and problem-solving skills. Fostering STEM integration is essential to fulfill the true potential of the “Merdeka Belajar” curriculum and achieve its original goals of Indonesian educational reform.

Fig. 3, derived from insights in the literature review section above, illustrates that the primary conjecture of why the “Merdeka Belajar” framework lacks attributes for STEM integration is due to the separate implementation of the “Merdeka Belajar” curriculum and STEM learning policy. Additionally, the ongoing common issues in implementing education policies and the historical hurdles of curriculum reform pose significant obstacles to integrating STEM education in a broader context of Indonesia’s education system. Moreover, the COVID-19 pandemic has further exacerbated the existing challenges. These obstacles indicate that the widespread implementation of the “Merdeka Belajar” across all education levels by 2024 falls short of the government’s target.

Fig. 3. Problems and Potential Solutions in Implementing Education Policies in Indonesia



As outlined in Fig. 3, the following four potential solutions might be an alternative to address the challenges of STEM integration within the “Merdeka Belajar” curriculum.

1. Connection between educational content and industry demands
   Educational content should bridge the gap between theoretical knowledge and industry needs. Studies [5], [6], [9], [12], [13] emphasize the importance of practical experiences for students through partnerships and collaborations with other universities, industries, and international organizations. These collaborations facilitate access to resources, expertise, and real-world contexts, enhancing the relevance of educational content to the evolving demands of the workforce, which ultimately prepares students for successful careers.

2. Governance decentralization
   Decentralized governance is crucial for integrating STEM education effectively into the "Merdeka Belajar" curriculum. Although the School-based curriculum has been implemented since 2006, it has not fully allowed schools to design their own curriculum. According to Wang et al. [9] and the Directorate for Education and Skills [15], the current centralized curriculum governance in Indonesia restricts schools' ability to customize learning for their specific needs. This condition limits educators from tailoring teaching strategies to suit their unique contexts. In addition, literature [5], [6], [9], [12], [13] points out the need for awareness-raising efforts at both the government and teacher levels, which can be better achieved through regional control instead of a top-down approach controlled directly by the Ministry of Education. Decentralizing curriculum governance to regional control allows educators to design projects and learning activities that leverage the strengths of teachers' and students' interests, which ultimately empowers educators to tailor STEM education to their communities, fostering innovation and personalized instruction.
3. Educator upskilling
   Educator upskilling is critical to elevating teachers' understanding of STEM learning and its philosophy. Nugroho et al. [6] highlight that teachers require comprehensive training and professional development opportunities encompassing STEM pedagogy, curriculum design, and subject integration. However, Wang et al. [9] revealed that there is limited access to high-quality training and development programs for teachers who reside outside Indonesia's major island, Java. This inequality in access not only impedes the development of teachers but also obstructs the implementation of innovative teaching methodologies essential for fostering STEM competencies among students. Ensuring equitable access to quality training and resources will fortify the foundation of STEM education within the "Merdeka Belajar" framework.
4. Creative thinking and innovation
   The "Merdeka Belajar" curriculum's emphasis on deep learning approaches through flexible learning structures and project-based learning creates a perfect environment for fostering creativity and innovation in STEM education. Arlinwibowo et al. [5] highlight that STEM projects inherently require students to think creatively and solve real-world problems, echoing the call of Veza et al. [12] for Indonesian engineering education reform that incorporates project-based learning and design experiences for cultivating critical thinking, problem-solving, and creativity. One way to facilitate creative thinking and innovation is by advocating for technology integration in STEM education, such as using simulations, data analysis software, and online resources [6]. Teachers can use such technologies to create engaging environments that empower students to think critically and creatively as they tackle real-world challenges.

Recommendations and Implications for Policy and Practice

The "Merdeka Belajar" framework depicted in Fig. 2 discovers the need to change Indonesia's most recent education policy because of the missing key features of its one strategy for transforming teaching and learning through the integration of STEM disciplines. The alternatives proposed for filling out the missing key features involve promoting collaborations between educational institutions and industries, decentralizing curriculum governance, ensuring equal access to professional development, and incorporating digital technologies to facilitate creative thinking and innovation.

Policymakers should cultivate collaborations between educational institutions and industries to align educational curricula with industry needs. This can be done through guest lectures, industry visits, internships, or collaborative project developments. As underlined by Nugroho et al. [6] and Olivia Nuestro [13], partnership and collaboration with external organizations provide students with hands-on experience that benefits them in competing in the job market. Besides, as policymakers, the government should implement curriculum governance from a centralized, top-down approach to a regional control model. Practicing this approach will allow educators to customize their instructional programs to meet local demands [6], [9]. The subsequent policy recommendation is the need to provide equitable opportunities for high-quality STEM training and professional development programs for all educators across Indonesia's archipelago. This can be realized by developing online training modules. Utilizing online resources [6] may help educators possess similar STEM knowledge levels and skills to effectively implement STEM education within the "Merdeka Belajar" framework. Similarly, the final policy recommendation encourages policymakers to provide infrastructure, particularly in digital format, to facilitate critical thinking, problem-solving, and creativity for both instructors and learners through project-based learning. As highlighted by Nugroho et al. [6], educators can incorporate simulations, data analysis tools, and online resources to create engaging learning experiences. Integrating such technologies will help students develop essential skills needed for the challenges of the 21st century and the Fourth Industrial Revolution.

Connection to Leadership, Policy, and Change

The evaluation of the "Merdeka Belajar" curriculum as an education policy involves the discovery process by criticizing the misalignment between existing characteristics and one of the policy attributes used to achieve the goal set by the policymakers. Besides, it involves identifying various challenges as well as formulating potential solutions to address them. The steps taken in the evaluation process follow the strategies proposed by [17], who stated that commenting on policy can take various forms, including critiquing existing policies, revising existing ones, promoting innovative practices, active participation in meetings, and addressing challenges from global economic and technological changes. Furthermore, the proposed potential solutions for changing the policy highlight the need for collaboration in the change process, as outlined by Rippner [17] and Kezar [18], who similarly discussed that collaboration, meaning involving people in the change process and working together, builds buy-in from diverse groups, are keys for improving public policy.

Acknowledgment

The authors would like to thank Dr. Joyce Main, Dr. Alexander Jannini, Dr. Sean Brophy, and Shauna Adams for their invaluable academic mentorship, critical insights. and thoughtful advice throughout the development of this work.

References

[1] OECD, *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*. in PISA. Paris: OECD Publishing, 2023. doi: 10.1787/53f23881-en.

[2] D. Riyan Rizaldi and Z. Fatimah, "Merdeka Curriculum: Characteristics and potential in education recovery after the COVID-19 pandemic conditions," *International*

Journal of Curriculum and Instruction, vol. 15, no. 1, pp. 260–271, 2022, [Online]. Available: https://orcid.org/0000-0000-0000-0000

[3] H. Elmunsyah, "A national education policy-based ICT model for Indonesian vocational high schools (VHS)," *Global Journal of Engineering Education*, vol. 16, no. 3, pp. 136–140, 2014.

[4] D. Wahyudin and A. Suwirta, "Politics of curriculum in the educational system in Indonesia," *TAWARIKH: Journal of Historical Studies*, vol. 11, no. 2, pp. 143–158, 2020, [Online]. Available: www.journals.mindamas.com/index.php/tawarikh

[5] J. Arlinwibowo, H. Retnawati, R. G. Pradani, and G. N. Fatima, "STEM implementation issues in Indonesia: Identifying the problems source and Its implications," *Qualitative Report*, vol. 28, no. 8, pp. 2213–2229, 2023, doi: 10.46743/2160-3715/2023.5667.

[6] O. F. Nugroho, A. Permanasari, and H. Firman, "The movement of STEM education in Indonesia: Science teachers' perspectives," *Jurnal Pendidikan IPA Indonesia*, vol. 8, no. 3, pp. 417–425, Sep. 2019, doi: 10.15294/jpii.v8i3.19252.

[7] N. Gaus, M. Yunus, A. Karim, and H. Sadia, "The analysis of policy implementation models in higher education: the case study of Indonesia," *Policy Studies*, vol. 40, no. 1, pp. 92–109, Jan. 2019, doi: 10.1080/01442872.2018.1539224.

[8] B. Y. Moeliodihardjo, "Higher education sector in Indonesia,"

[9] C. Wang, M. Zhang, A. Sesunan, and L. Yolanda, "Technology-driven education reform in Indonesia: A look into the current status of the Merdeka Belajar program," 2023.

[10] V. Sukmayadi and A. Halim Yahya, "Indonesian education landscape and the 21st century challenges," *Journal of Social Studies Education Research*, vol. 11, no. 4, pp. 219–234, 2020, [Online]. Available: www.jsser.org

[11] Kemdikbud RI, "Statistik Pendidikan." Accessed: Jan. 09, 2025. [Online]. Available: http://statistik.data.kemdikbud.go.id/index.php/

[12] I. Veza, M. Farid, M. Said, T. Widodo, B. Riyadi, M. A. Abas, and Z. A. Latiff, "Issues in the science and engineering education in Indonesia: how to improve competitiveness through STEM mastery," *International Journal of Advanced Research in Future Ready Learning and Education*, vol. 24, pp. 1–6, 2021.

[13] M. P. Olivia Nuestro, "Indonesia: Engineering education development project," 2009.

[14] R. Haridza and K. E. Irving, "The Evolution of Indonesian and American Science Education Curriculum: A Comparison Study," *International Journal for Educational Studies*, vol. 9, no. 2, pp. 95–110, 2017, [Online]. Available: www.mindamas-journals.com/index.php/educare

[15] Directorate for Education and Skills, "Transforming education in Indonesia: Examining the landscape of current reforms," 2023. [Online]. Available: https://www.oecd.org/pisa/data/2022database

[16] R. Farwati, K. Metafisika, I. Sari, D. S. Sitinjak, D. F. Solikha, and S. Solfarina, "STEM education implementation in Indonesia: A scoping review," *International Journal of STEM Education for Sustainability*, vol. 1, no. 1, pp. 11–32, Jul. 2021, doi: 10.53889/ijses.v1i1.2.

[17] J. A. Rippner, *The American education policy landscape*. Routledge, 2016.

[18] A. Kezar, *How colleges change*, 2nd ed. Hoboken: Taylor and Francis, 2018.